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Emergence and Yield of Beans Planted with a Seed-Orienting Planter

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ABSTRACT

Recent observations from an unrelated bean (*Phaseolus vulgaris* L.) field experiment indicated a possible relationship between emergence and seed orientation. To test the benefits of a "lay flat" orientation, a furrow opener was developed that horizontally orients bean seeds at uniform soil depths. Beans planted through this furrow opener emerged through the soil crust sooner and in significantly greater numbers than did those planted with a standard two-disk furrow opener. Oriented and unoriented plantings of dry and snap beans did not differ in final total emergence. Nevertheless, early snap bean yields were greater from the seed-oriented plots. Increased yield was due to earlier emergence, and uniform depth of planting. On uncrusted soil, seed orientation did not significantly increase dry bean yield.

Additional index words: Soil crust, Seedling emergence.

GREENHOUSE studies showed that bean (*Phaseolus vulgaris* L.) seedlings emerge through crusted soils sooner and in greater numbers if the seeds are planted either horizontally or with the hypocotyl end up (1). Because bean cotyledons always emerge hypocotyl end first, seed orientation influences the amount of rotation required for emergence. For example, seeds planted hypocotyl end down must rotate as much as 180° before emerging. Seeds planted other than horizontally or hypocotyl end up may be unable to rotate, or the additional time required for rotation allows soil crusts to form and retard emergence.

This experiment was established to evaluate a field planter capable of orienting bean seeds horizontally and to determine the influence of orientation on emergence and yield.

MATERIALS AND METHODS

The planter (Fig. 1 to 3) has a shoe which forms a smooth, flat surface for beans. Beans falling on this surface almost always orient themselves horizontally or in the "lay flat" position 11 (1). Seeds drop from the hopper into a curved tube, 1.86 cm (3/4 inch) in diameter, which extends to the rear of the shoe (Fig. 2). The tube eliminates bounce and the beans are deposited horizontally on the soil surface. Figure 1 shows the orienting planter and a planter with a standard two-disk furrow opener.

To determine the velocity of the bean seed as it emerged from the planter, two photosensors were positioned a known distance apart near the exit of the drop tube. The electric pulses gene-

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rated by the seed passing across the sensors controlled a Dana Model 8015[3] electronic counter/timer. The velocity resolution was 0.01 m/s and the average speed of the seed emerging from the planter was 1.6 m/s (3.6 mph). A planter traveling at normal planting speed would deposit seed on the soil surface at a low velocity, thus eliminating tumbling of the seed.

Three field trials were conducted with the newly developed planter. The treatments were 1) beans planted through a standard two-disk furrow opener and 2) beans planted with the seed-orienting furrow opener. In each trial the soil was Portneuf silt loam. No fertilizer was applied, and there was no visual evidence of moisture deficiency during the season.

[3] Trade names or company names are included to provide specific information and do not imply endorsement or warranty by the USDA.

Fig. 1. Orienting and standard planter mounted on tractor tool bar.

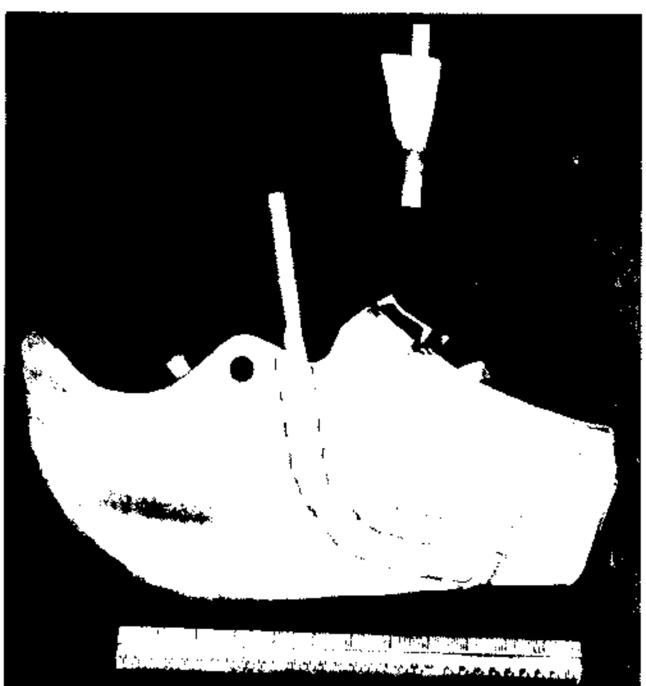

Fig. 2. Orienting planter "shoe" and component parts.

Experiment 1 (1970) consisted of the above two treatments replicated six times. The plots, 2.43 m wide (4 rows) by 45.6 m long, required no preirrigation and were planted on June 19 with 'Pinto UI-114' beans. The plots were irrigated four times during the season. Emergence counts and yields were taken on two randomly selected subplots, 1.22 × 3.04 m, in each main plot. Emergence counts were started June 24 and continued until June 26 when emergence ceased. Dry bean yields were harvested on September 25.

The statistical design was a completely randomized block with analysis of variance based on "nested samples" (2). The associated "F" test and $LSD_{.05}$ were used to detect significant differences in emergence counts and yields.

Experiment 2 (1972) was planted with 'Canyon' snap beans on June 1. The plots were 2.43 m wide (4 rows) and 42.5 m long with plant spacing of approximately 8.7 cm. Emergence from the two center rows of each plot was counted daily from June 6 to 19. Snap beans were hand-picked from one row in each plot on three dates: August 11, August 14, and August 17. Emergence counts and yields were made on rows 36.6 m long. Bean pods were sieved and separated into six sizes.

The plots were preirrigated May 25 and irrigated four times thereafter. Rainfall of 0.48, 0.45, 0.33, and 0.76 cm on June 6, 7, 8, and 9, respectively, caused formation of about a 2-cm thick crust. The statistical design was a completely randomized block consisting of two treatments and three replications. Analysis of variance, "F" test, and $LSD_{.05}$ were determined for daily emergence and for the yields from each of the three harvests.

A cooperative field seed man determined the picking date on which his company would normally make a one-time harvest for the sieve size of the snap beans they would prefer. A picking 2 days in advance and one 2 days after were made to furnish sieve size of the snap bean data which other companies would be interested in for their particular pack.

A planting was made in October 1972 (experiment 3) for precisely measuring planting depths. Depths were determined on 150 seeds from each treatment planted in leveled soil. A wooden rail 8.6 cm high was placed on each side of each of two seed rows: one row oriented and the other standard. A straight edge, placed across the leveled rails, was used as a reference. Bean seeds in each row were carefully uncovered and their depths measured from the reference. Average planting depth and standard deviations were calculated for each treatment.

RESULTS AND DISCUSSION

Table 1 gives the average cumulative seedling emergence for experiment 1. First-day June 24 emergence of oriented seeds was significantly greater than that of

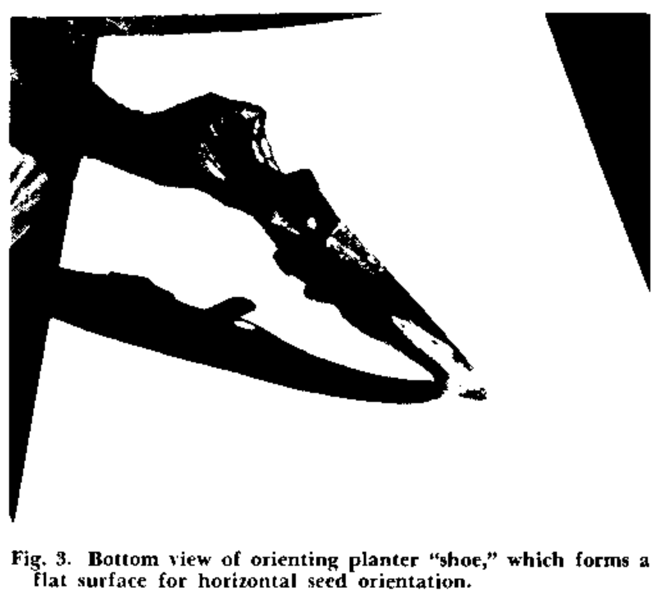

Fig. 3. Bottom view of orienting planter "shoe," which forms a flat surface for horizontal seed orientation.

Table 1. Average daily cumulative bean seedling emergence for experiments 1 and 2.

	Experiment 1, 1970			Experiment 2, 1972								
	Jun 24	Jun 25	Jun 26	Jun 6	Jun 7	Jun 8	Jun 9	Jun 10	Jun 12	Jun 13	Jun 16	Jun 19
	Number of Plants											
Furrow opener	45,300	126,030	147,330	5,230	21,080	71,169	89,770	97,620	101,960	102,780	111,900	118,330
Two-disk	18,600	110,110	146,210	820	2,220	17,420	29,330	36,550	41,780	43,580	95,830	112,810
LSD $_{.05}$	23,370	19,130	46,650	1,420	3,370	12,080	16,500	18,770	19,240	21,600	20,250	20,560

unoriented seeds, but there was no significant difference on June 25 and June 26. The difference in emergence over this short period may be partially due to the high vigor of the seedlot used.

The average dry bean yields from oriented and unoriented plots were 3.24 and 3.08 metric tons/ha, respectively. Although not significant, the yield difference was probably due to the slightly longer growing period for the oriented treatment.

Table 1 also shows the average daily cumulative seedling emergence from experiment 2. Through June 13, 1972, emergence was significantly greater from the oriented planting than from the unoriented planting. Emergence was stimulated by an inadvertent harrowing of all plots on June 13. The oriented planting, which already had good emergence, was only slightly affected by the breaking of soil crusts.

Table 2 gives average yields in total and by pod sizes for each of three harvests of snap beans. The first yields from the oriented treatment were significantly greater than those from the unoriented planting except for composite size 1, 2, and 3. The oriented treatment in the second picking resulted in significantly greater yields except for sieve sizes 1, 2, 3, and 4. In the third picking, only size 6 of the oriented treatment showed a significantly greater yield. This loss of significance in the third picking indicates that standard treatments, given sufficient growing time, would probably equal the oriented treatments in total yield.

Most canneries prefer a single harvest when they can obtain the maximum yield in the particular sieve size needed for whole, cut, or french style pack. Sieve sizes 1, 2, and 3 are used for whole green beans. Size 4 sieve is used for cut green beans and sieve size 5 and over are used for french style. These sieve sizes can vary slightly between companies depending upon their individual needs. Table 2 shows that the total yield with the seed-orienting furrow opener is greater than the standard two-disk furrow opener at each harvest date, although differences in yield of individual sieve sizes also appear for each date.

The best time for harvesting is determined primarily by field estimates of bean yield and fiber percentage. Fiber percentages were not measured in this experiment, but field estimates indicated the second picking to be most suitable for canning. For this picking the total yield of oriented beans exceeded the standard plantings by 3.7 metric tons/ha or 47%.

Table 2. Average total and sieve size yields of Canyon green beans.

Type of planter	Harvest date		Pod Size Class				
			1, 2, 3	4	5	6+	Total
			Average yield, metric tons/ha				
Furrow Opener	Aug. 11		2.00	1.38	2.40	2.00	7.76
Two-disk	Aug. 11		1.73	0.88	1.47	1.01	5.09
		LSD $_{.05}$	0.99	0.39	0.59	0.33	1.75
Furrow Opener	Aug. 14		1.77	1.77	3.36	4.61	11.50
Two-disk	Aug. 14		1.81	14.7	2.23	2.29	7.80
		LSD $_{.05}$	0.36	0.61	0.30	1.15	2.13
Furrow Opener	Aug. 17		1.65	2.28	3.59	5.06	12.57
Two-disk	Aug. 17		1.51	2.06	3.02	3.46	10.05
		LSD $_{.05}$	0.19	0.55	1.21	0.59	2.97

One can only speculate about the possible results if soil crusts had not been broken. By June 13, the day crusts were broken, the rate of emergence on the standard treatment had decreased and would soon cease. On that date the average oriented emergence exceeded the standard by 59,200 plants/ha (Table 1). Removal of soil crusts only slightly enhanced oriented plantings, but greatly enhanced that of standard plantings. It is therefore reasonable to assume that the yields from standard plantings would have been much lower if the crusts had not been broken.

The favorable effects of oriented plantings are not restricted to seed orientation. Average planting depths by the orienting and the standard furrow openers were 6.3 ± 0.4 cm and 5.2 ± 1.0 cm, respectively. The smaller standard deviation of the oriented beans should insure more uniform emergence because more seeds are planted at the same level. In effect, depth of planting is more precise with the seed-orienting furrow opener.

Although not verified, the rapid emergence of oriented seed may be influenced by a favorable soil moisture regime. In forming the flat surface the underlying soil is relatively undisturbed. This undisturbed soil may allow more rapid flow of water to the seed and thus earlier germination.

ACKNOWLEDGMENT

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